

UDC 666.65:621.315.62

PROPERTIES OF HIGH-VOLTAGE PORCELAIN WITH ALUMINA-CONTAINING RAW MATERIAL FROM UZBEKISTAN

G. T. Adylov,¹ G. V. Voronov,¹ N. A. Kulagina,¹ É. P. Mansurova,¹ and M. Kh. Rumi¹

Translated from *Steklo i Keramika*, No. 12, pp. 22–23, December, 2007.

The results of investigations performed to determine the possibility of using local raw material from Uzbekistan for obtaining electrical ceramic are presented. The properties of ceramic are studied as a function of the chemical composition of pegmatites from different deposits. It is found that the electrical characteristics depend on, first and foremost, the content of oxides of alkali elements in porcelain and to a much lesser degree on the ratio $K_2O : Na_2O$ in silica-containing raw material.

Even though new electric insulation materials have appeared, electrical porcelain, which is used for fabricating various articles used for electrical purposes, remains the most widely used.

The quality of articles made of high-voltage porcelain depends on many factors, including the chemical composition and the stability of the initial raw materials. Feldspar and quartz-feldspar raw material must meet special requirements. However, because of existing difficulties due to the absence of high-quality feldspars or pegmatites in Uzbekistan, it is now necessary to investigate the use of various forms of local, including silica-containing, raw material to produce electrical porcelain.

Pegmatites from different deposits (Lyangarskoe, Ingichinskoe, Uchdukskoe) and quartz-sericite porcelain stone from the Boinaksaiskoe deposit (Table 1) were used for the

investigations. Analysis of the chemical composition of the raw materials following the requirements of GOST 7930–75 showed that according to one control indicator — the total quantity of alkali-earth oxides and the ratio $K_2O : Na_2O$ (potassium modulus) — preference had to be given to porcelain stone and according to another control indicator (the content

TABLE 2.

Raw material	Mass content, %, in mass			
	I-5u	I-5	I-5i	I-14
Quartz-sericite rock	35	35	35	25
Primary kaolin AKS-30	29	29	29	35
Pegmatite:				
Uchkuduskoe	15	—	—	—
Lyangarskoe	—	15	—	—
Ingichinskoe	—	—	15	—
Druzhkovskoe clay	21	21	21	25
Porcelain insulator scrap	—	—	—	15

TABLE 1.

Raw material	Mass content, %							
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	CaO	MgO	K ₂ O	Na ₂ O
Quartz-sericite rock	80.53	14.58	0.36	0.20	0.05	0.26	3.61	0.41
Angren kaolin AKS-30	63.10	33.56	1.06	0.50	0.11	0.11	1.30	0.50
Druzhkovskoe clay	56.06	38.60	0.90	1.23	0.40	1.03	0.99	0.79
Pegmatite:								
Lyangarskoe	72.10	15.16	0.17	0.67	1.52	1.03	6.91	3.20
Ingichinskoe	73.10	14.98	0.46	0.14	1.68	0.20	4.20	4.82
Uchkuduskoe	71.87	15.58	0.23	0.14	1.13	0.10	8.16	2.78
Porcelain insulator scrap	67.24	26.22	0.58	0.55	1.39	0.81	2.01	1.20

TABLE 3.

Indicator	Experimental paste					
	I-5u	I-5	I-5i	I-14		
Calcination temperature, °C	1250	1300	1250	1300	1250	1300
Total shrinkage, %	8.95	10.20	8.72	8.80	8.80	9.88
Apparent density, g/cm ³	2.38	2.46	2.49	2.47	2.45	2.49
Open porosity (color in magenta)			Absent			
Water absorption, %	0.30	0.17	0.08	0.04	0.07	0.04
Electric strength, kV/mm	—	25	—	28	33	36
Tangent of the dielectric losses angle, 10 ⁻³	—	19.50	—	18.10	17.80	16.60
Permittivity	—	7.2	—	7.0	6.8	6.1
Content in porcelain, %:						
K ₂ O + Na ₂ O	3.88	3.88	3.75	3.75	3.59	2.47
quartz	—	34.18	—	34.49	34.63	35.43

of alkali oxides, Fe₂O₃ and free quartz) preference had to be given to pegmatites. Consequently, a combination of these components was used to determine the mass compositions.

It should be noted that pegmatites from various deposits also differed according to the parameters listed above. Angren kaolin AKS-30 was used as the main clay component. However, since it contains an elevated content of quartz, plastic clay from the Druzhkovskoe deposit (Ukraine) was added to the mass. In addition, a material in which porcelain insulator scrap was used instead of pegmatite was investigated for comparison. The batch composition was calculated according to a prescribed chemical composition of high-voltage porcelain. The experimental masses of high-voltage porcelain are presented in Table 2.

Samples made by semidry pressing from finely dispersed mass were calcined in a Silit furnace in air at temperatures 1250 and 1300°C. X-ray phase analysis of the synthesized materials was performed on a DRON-UM-1 diffractometer (CuK_α radiation). The properties of the porcelain pastes which were developed were determined according to GOST 24408–89 using standard samples (Table 3).

Analysis of the results showed that all ceramic materials investigated possessed nearly zero open porosity and good mechanical strength (above 70 MPa) irrespective of the form of the silica-containing raw material. A distinct dependence of the electrical characteristics on, first and foremost, the content of oxides of alkali elements in porcelain and to a much lesser extent on the ratio K₂O : Na₂O in silica-containing raw material was found. As the content of (K₂O + Na₂O) decreased from 3.88 to 2.48% the electrical strength increased from 25 to 36 kV/mm, and the tangent of the dielectric losses angle decreased from 0.0195 to 0.0166 and from 7.2 to 6.1, respectively. The decrease of the permittivity and of the tangent of the dielectric losses angle was also due to, in our opinion, an increase in the content of quartz and a decrease of the amount of the glass phase in porcelain.

The last assertion is at variance with the opinion [1] that an increase of the quantity of the glass phase in electrical ce-

ramic gives rise to a decrease of the tangent of the dielectric losses angle. The characteristics obtained corresponded completely to the requirements of the standard for electrical material based on silicate porcelain with aluminum oxide content not exceeding 30%. The materials obtained belong to this class. But, according to published data [2, 3], feldspar raw material with potassium modulus of at least 4 must be used to obtain porcelain with the tangent of the dielectric losses angle equal to 0.020–0.022, corresponding to the level for the best samples. Only porcelain stone (K₂O : Na₂O = 8.8) met this requirement. In all pegmatites which we used the value of this angle did not exceed 3. The presence of cristobalite in the phase composition of porcelain had a much greater effect on the properties of the porcelain; the amount of cristobalite increased as the calcination temperature increased from 1250 to 1300°C. This agrees well with the opinion [2] that heat treatment regimes which promote cristobalitization of quartz are necessary to obtain materials with improved characteristics.

In summary, when choosing initial components for synthesizing high high-voltage porcelain, feldspar raw material which does not completely meet the state standard can be used. A combination of different types of silica-containing raw material and optimization of the technological process regimes which give the prescribed chemical and phase composition of the ceramic make it possible to obtain electrical porcelain with characteristics corresponding to the requirements of the standard.

REFERENCES

1. V. P. Il'ina and I. S. Inina, "Investigation off the possibility of using unconventional feldspar rocks from Karelia for electrical ceramic," *Ogneup. Tekh. Keram.*, No. 10, 40–5 (2006).
2. G. N. Maslennikov (ed.), *Technology of Electroceramics* [in Russian], Énergiya, Moscow (1974).
3. G. N. Maslennikov and A. F. Buchenkova, *Raw Materials and Calculation of High-Voltage Porcelain Pastes* [in Russian], Informélektro, Moscow (1969).